

CLAIMS

1. A Micro-Opto-Electro-Mechanical Waveguide Switch (MOEM-WS) comprising:
  - 5 a micromachined planar lightwave circuit (PLC) substrate having at least one integrated optical waveguide fabricated thereto and at least one optical fiber coupled into the integrated optical waveguide; and
  - 10 a micro electromechanical actuator on the micromachined PLC substrate to move and align sender waveguide ports relative to a plurality of receiver waveguide ports
- 15 2. The MOEM-WS as cited in claim 1, wherein said micromachined PLC substrate comprising a silicon-on-insulator (SOI) wafer upon which said micromachined PLC and said micro electromechanical actuator being constructed.
- 20 3. The MOEM-WS as cited in claim 1 further comprises a support substrate, wherein the support substrate being bonded to the said micromachined PLC substrate.
- 25 4. The MOEM-WS as cited in claim 1, providing 1-input/N-output (1XN) fiber switching or N-input/1-output (NX1) fiber switching, wherein the port number N being any positive integer numbers and being determined by the number of waveguide ports on the said micromachined PLC.
- 30 5. The MOEM-WS as cited in claim 1, wherein said at least one integrated optical waveguide of PLC supporting one electromagnetic wave propagation mode along the waveguide.
6. The MOEM-WS as cited in claim 1, wherein said at least one integrated optical waveguide of PLC supporting a plurality of electromagnetic wave propagation modes along the waveguide.

7. The MOEM-WS as cited in claim 1, wherein said at least one integrated optical waveguide of PLC comprising a core and adjacent cladding, and said core and cladding comprising a glass material.
- 5 8. The MOEM-WS as cited in claim 1, wherein said at least one integrated optical waveguide of PLC comprising a core and adjacent cladding, and said core and cladding comprising a polymer material or any other types of materials for electromagnetic wave propagation.
- 10 9. The MOEM-WS as cited in claim 1, further comprises a plurality of electrically conductive pathways on said micromachined PLC substrate or said support substrate.
- 15 10. The MOEM-WS as cited in claim 1, further comprising photonic or electronic integrated circuits mounted on said micromachined PLC substrate for optical signal generation/detection or subsequent electronic signal processing.
- 20 11. The MOEM-WS as cited in claim 1, wherein said micro electromechanical actuator comprising a moving cantilever flexure, upon which sender or receiver waveguide ports reside, and said micro electromechanical actuator providing a horizontal movement of the sender or receiver waveguide ports relative to the other waveguide ports on the opposite side, wherein the horizontal movement being either linear or angular displacement.
- 25 12. The MOEM-WS as cited in claim 1, wherein said micro electromechanical actuator utilizing a variety of MEMS side actuation mechanisms including electrostatic, magnetic, thermal, shape memory alloy, impact, and piezoelectric actuations, and any other applicable MEMS actuation methods.
- 30 13. The MOEM-WS as cited in claim 1, wherein said micromachined PLC having silicon microgrooves filled with the same material for integrated optical waveguide in order

to avoid the peeling between integrated optical waveguide layer and the silicon structure layer.

14. The MOEM-WS as cited in claim 1, wherein said micromachined PLC having  
5 tapered waveguide ports to increase the optical signal coupling efficiency and to reduce the alignment accuracy requirements between the movable waveguide port relative to the other waveguide ports on the opposite side, wherein, the tapered waveguide ports being either symmetric or asymmetric.

10 15. The MOEM-WS as cited in claim 1, providing a cascaded fiber switch array to expand the scale and functionality of MOEM-WS, wherein a large-scale cascaded fiber switch array comprising a plurality of serially interconnected small-scale fiber switch arrays on a single substrate.

15 16. The MOEM-WS as cited in claim 1, providing a full-duplex fiber switch, wherein said micromachined PLC comprising dual-channel waveguides at both ports of sender and receiver waveguides for concurrent forward and backward signal propagation in order to support bi-directional and full-duplex signal transmissions.

20 17. The MOEM-WS as cited in claim 1, providing a 2-input/2-output crossbar fiber switch, wherein said micromachined PLC comprising three waveguide channels at both sender and receiver waveguide ports, and further wherein, one of the receiver waveguide port being looped back into the appropriate sender waveguide port in order to construct "bar" and "cross" states.

25 18. A Micro-Opto-Electro-Mechanical Cross-connect (MOEM-XC) switch comprising:  
an input array of M MOEM-WS with a sequence of electrical control signals for actuation, wherein the individual MOEM-WS having a 1XN fiber switch configuration, and  
30 further wherein, M (number of MOEM-WS) and N (fiber switch port number on the individual MOEM-WS) being any positive integer numbers; and

an output array of  $M$  MOEM-WS with a sequence of electrical control signals for actuation, wherein the individual MOEM-WS having a  $N \times 1$  fiber switch configuration, and further wherein,  $M$  (number of MOEM-WS) and  $N$  (fiber switch port number on the individual MOEM-WS) being any positive integer; and

a fiber transpose block providing a static interconnection between  $M \times N$ -output-ports of the input array of  $M$  MOEM-WS and  $M \times N$ -input-ports of the output array of  $M$  MOEM-WS, wherein  $M$  (number of MOEM-WS) and  $N$  (fiber switch port number on the individual MOEM-WS) being any positive integer numbers.

19. The MOEM-XC switch as cited in claim 18, wherein said fiber transpose block comprising three sub-blocks: 1)  $M \times N$ -input fiber-to-fiber connector block, 2)  $M \times N$ -input/ $M \times N$ -output fiber-hold block; and 3)  $M \times N$ -output fiber-to-fiber connector block.

20. The fiber transpose block as cited in claims 18 and 19, wherein said input array of  $M$  MOEM-WS and said output array of  $M$  MOEM-WS being cross-connected either by cross-connecting fibers between said  $M \times N$ -input fiber-to-fiber connector block and input ports of said  $M \times N$ -input/ $M \times N$ -output fiber-hold block or by cross-connecting fibers between output ports of said  $M \times N$ -input/ $M \times N$ -output fiber-hold block and said  $M \times N$ -output fiber-to-fiber connector block.

21. The fiber transpose block as cited in claims 18 and 19, wherein said  $M \times N$ -input/ $M \times N$ -output fiber-hold block comprising silicon V-groove microstructures to place and hold arrays of optical fibers, and further wherein, the optical fibers supporting a single or a plurality of electromagnetic wave propagation modes and further comprising a core and adjacent cladding, and the said core and cladding comprising glass, polymer or other type of materials for electromagnetic wave propagation.

22. A hierarchical matrix architecture for a large-scale fiber transpose block comprising:

an input ribbon connector block matrix, wherein the individual matrix element being  
input fiber-to-fiber connector block; and

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an output ribbon connector block matrix, wherein the individual matrix element being  
output fiber-to-fiber connector block; and

10 a fiber-hold block matrix, wherein the individual matrix element being input/output fiber-  
hold block.

15 23. The hierarchical matrix architecture as cited in claim 22, wherein said input and  
output ribbon connector block matrices being cross-connected either by cross-connecting  
the fiber bundles between said input ribbon connector block matrix and input ports of  
said input/output fiber-hold block matrix or by cross-connecting the fiber bundles  
between output ports of said fiber-hold block matrix and said output ribbon connector  
block matrix.